

ECOSYSTEM MONITORING AND MANAGEMENT

3.1 Dr Hewitt presented the report of the meeting of WG-EMM which was held from 18 to 29 August 2003 in Cambridge, UK (Annex 4). Intersessional activities had been conducted by correspondence groups on: the analysis of CEMP data, modifications to the *CCAMLR Scientific Observers Manual*, ecosystem modelling approaches, the design of land-based krill predator surveys, and the subdivision of CCAMLR statistical areas into ecologically-based harvesting units. During the meeting, the Advisory Subgroup on Protected Areas, the Subgroup on CEMP Methods, the steering committee for the upcoming workshop on modelling approaches, the correspondence group on predator surveys, an ad hoc subgroup on interpretation of CEMP indices, and an ad hoc subgroup on evaluation of fisheries-derived indices of krill availability met. Also during the meeting, a workshop to review CEMP was conducted.

3.2 Conveners of these subgroups were:

- CEMP Data Analyses – Dr Southwell and Prof. Croxall;
- *Scientific Observers Manual* – Dr S. Kawaguchi (Japan);
- Modelling Approaches – Dr Constable;
- Predator Surveys – Dr Southwell;
- Harvesting Units – Dr Nicol and Dr M. Naganobu (Japan);
- Designation of CEMP Sites – Dr P. Wilson (New Zealand) on behalf of Dr Penhale;
- Methods – Dr Reid;
- Interpretation of CEMP Indices – Dr Reid and Dr G. Watters (USA);
- Fisheries-derived Indices of Krill Availability – Dr Hewitt;
- CEMP Review Workshop – Prof. Croxall and Dr Southwell.

3.3 These activities are summarised in three documents for consideration by the Scientific Committee:

- (i) report of WG-EMM-03 (Annex 4) containing a listing of ‘Key Points for Consideration by the Scientific Committee’ at the end of each major agenda item, as well as the Report of the CEMP Review Workshop (Annex 4, Appendix D);
- (ii) synopses of working papers (SC-CAMLR-XXII/BG/6) considered at the meeting, each containing an abstract and a summary of the findings and/or conclusions as they relate to a particular agenda item;
- (iii) report of the Convener of WG-EMM-03 to SC-CAMLR-XXII (SC-CAMLR-XXII/BG/15) containing appropriate references to paragraphs in the report of WG-EMM-03 (Annex 4).

3.4 Dr Hewitt noted that, similar to recent years, the agenda of WG-EMM-03 was structured to consider the status and trends in the krill fishery, the status and trends in the krill-centric ecosystem, and the status of management advice arising from these considerations.

CEMP Review Workshop

3.5 Dr Hewitt reviewed the history of CEMP which was established in 1987 with two objectives:

- (i) detect and record significant changes in critical components of the ecosystem;
- (ii) distinguish between changes due to the harvesting of marine resources and changes due to environmental variability.

3.6 In 2001 the Scientific Committee agreed, as part of its scheduled plan of work, to commence a review of CEMP at the 2003 meeting of WG-EMM (SC-CAMLR-XX, paragraphs 4.2 to 4.7). The Scientific Committee established the following terms of reference for this review:

- (i) Are the nature and use of the existing CEMP data still appropriate for addressing the original objectives?
- (ii) Do these objectives remain appropriate and/or sufficient?
- (iii) Are additional data available which should be incorporated in CEMP or be used in conjunction with CEMP data?
- (iv) Can useful management advice be derived from CEMP or be used in conjunction with CEMP data?

3.7 A steering committee was established under the co-convenership of Prof. Croxall and Dr Southwell, a plan of intersessional work was adopted and analyses proceeded with considerable support from the Secretariat. The Report of the CEMP Review Workshop is included in Annex 4, Appendix D. Discussion of the workshop report at the meeting of WG-EMM is recorded in Annex 4, paragraphs 2.1 to 2.20.

3.8 During the intersessional period the CEMP datasets were validated and analyses undertaken related to:

- (i) serial correlation and power of the CEMP predator indices to detect change;
- (ii) functional responses between these indices and measures of krill availability.

Interpretation of these analyses as well as additional analyses were undertaken at the workshop.

3.9 The Scientific Committee endorsed the conclusion of the Working Group that serial correlation in the biological indices was not significant; however, indices derived from environmental and fisheries data exhibited more correlation between successive years. Further conclusions were that analysis of the various sources of variability in the CEMP indices and the consequences of such variability on the power to detect change would lead to improvements in the monitoring program. An example of this type of analysis for indices on Adélie penguins was developed at the workshop. The Scientific Committee recommended that such analyses be conducted on the full suite of CEMP indices in the near future.

3.10 The Scientific Committee endorsed the conclusion that krill predator performance was related to krill availability based on analysis of data collected at South Georgia and in the

South Shetland Islands, although the form of the relationship differs between the areas. Differences in predator performance between two years of observations in East Antarctica and the Ross Sea were attributed to changes in krill availability in the case of East Antarctica and environmental conditions in the case of the Ross Sea. Nevertheless, it may be possible to use the relationships between predator performance and krill availability for predicting krill availability and for developing a biological basis for the identification of years in which predator performance was anomalous. The Scientific Committee endorsed the recommendation that the data requirements and analytical procedures required to evaluate the indices of krill availability derived from fisheries data should be defined.

3.11 With regard to the first term of reference (Are the nature and use of the existing CEMP data still appropriate for addressing the original objectives?), the Scientific Committee agreed with the conclusion that CEMP data were appropriate for detecting and recording significant change in some critical components of the ecosystem, but further critical evaluation of the nature, magnitude and statistical significance of changes indicated by the data were necessary. Work also remains to determine how representative the CEMP sites are of their local areas and regions.

3.12 It was noted in Annex 4, paragraph 2.7 that:

- (i) at current harvesting levels it was unlikely that the existing design of CEMP, with the data available to it, would be sufficient to distinguish between ecosystem changes due to harvesting of commercial species and changes due to environmental variability, whether physical or biological;
- (ii) with the existing design of CEMP, it may never be possible to distinguish between these different and potentially confounding causal factors and that the Scientific Committee should seek advice from the Commission on the extent to which further work should be directed towards this topic;
- (iii) without a real ability to separate the confounding effects of harvesting and environmental variation and in the context of uncertainty, the Scientific Committee should seek advice from the Commission about the policy of how management should proceed when a significant change was detected, but no single causal factor could be attributed;
- (iv) one possible method that may assist in the separation of confounding effects of harvesting and environmental variation would be the establishment of an experimental fishing regime whereby fishing would be concentrated in local areas in conjunction with an appropriate predator monitoring program.

3.13 Dr Sushin cautioned that an experiment as described in paragraph 3.12(iv) might have financial implications for the fishery if efforts were directed to areas with low catch efficiencies.

3.14 The Scientific Committee agreed that:

- (i) with regard to the second term of reference (Do these objectives remain appropriate and/or sufficient?), the original objectives of CEMP remained

appropriate, but that a third objective ‘To develop management advice from CEMP and related data’ should be added;

- (ii) with regard to the third term of reference (Are additional data available which should be incorporated in CEMP or be used in conjunction with CEMP data?), many time series of non-CEMP data contain information of considerable value in addressing the objectives of CEMP. Also, the Secretariat should maintain a register of the wide range of non-CEMP time-series data that were of use to this workshop and of potential utility to future workshops in support of the work of WG-EMM, including datasets derived from South African and French seabird and pinniped monitoring programs in the southern Indian Ocean;
- (iii) additionally, useful indices of krill availability to land-based krill predators could be derived from fishery-dependent data; and indices derived from mackerel icefish data may be of value in monitoring krill in certain regions and should be subjected to the same analyses undertaken for CEMP data;
- (iv) with regard to the fourth term of reference (Can useful management advice be derived from CEMP?):
 - (a) functional responses linking predators to their prey field may be of utility in a management context;
 - (b) behavioural models based on interactions between the aspects of the environment, krill, krill predators and a krill fishery may also be of utility in a management context;
 - (c) simulation studies conducted during the workshop indicated that accounting for the nature of the variability of estimates of krill availability and predator performance could result in improved ability to detect anomalies.

3.15 The Scientific Committee noted a suggestion by Dr Gerrodette (invited expert) that the CEMP indices could be interpreted in a different way to that currently adopted. At present, an anomalous value of an index is one that is outside the normal range, as identified by a test of statistical or biological significance. This is equivalent to testing the null hypothesis of no change. A more appropriate test in the context of precautionary management may be of the null hypothesis that an undesirable change, as identified by the management objectives, has not occurred. This alteration in the ‘burden of proof’ is a common component of other precautionary management regimes.

3.16 The Scientific Committee noted that the workshop should be considered the first phase of the review of CEMP and laid out a plan of future work for WG-EMM. The most important of these tasks include:

- (i) completion of the review of sources and magnitudes of variability in predator response parameters;
- (ii) investigation of the utility of indices derived from haul-by-haul CPUE data as a proxy for direct measures of krill availability;

- (iii) investigation of alternative methods for determining anomalies and predicting krill abundance using predator response curves.

3.17 Prof. J. Beddington (UK) and Dr Constable cautioned that the use of CPUE data as a proxy of biomass could be problematic.

3.18 Looking forward to planned workshops in the future, the Scientific Committee noted the importance of the CEMP review to the selection of appropriate predator–prey–fishery–environment models (scheduled for 2004) and to the evaluation of alternative management procedures (scheduled for 2005).

3.19 Members thanked the Co-conveners Prof. Croxall and Dr Southwell and the Secretariat for their work in preparing for the workshop, and the USA for contributing to the travel support of invited experts.

Status and Trends in the Krill-centric Ecosystem

3.20 Dr Hewitt stated that the Working Group reviewed the status and trends apparent in the CEMP indices provided by the Secretariat and noted that there was little evidence of large-scale deviation from the long-term mean for most indices. However, there was evidence that indices of the performance of predators at Cape Shirreff were abnormally low and that unusual ice conditions in the Ross Sea continue to negatively impact on penguins in that region (Annex 4, paragraphs 4.1 to 4.5).

3.21 The Working Group recognised that the practice of tabulating anomalies in the CEMP indices with the intent of scoring a particular year as ‘good’ or ‘bad’ could be misleading. The Working Group proposed that an ordination approach be developed whereby the nature of the covariation in multivariate CEMP indices could be described and presented on an annual basis. This approach would have the potential to characterise the state of the system in relation to other years and to identify temporary shifts (i.e. anomalies), gradual changes (e.g. trends) or regime shifts. This would utilise all of the available data rather than being restricted to statistical anomalies. The Working Group requested the Secretariat to use this approach when presenting CEMP indices at its next meeting, but also recognised that the new approach may evolve over a longer period of time (Annex 4, paragraphs 4.9 to 4.18 and 4.106 and Figures 1 and 2).

3.22 The Scientific Committee welcomed the examination of alternative approaches to presenting CEMP indices and noted the previous endorsement by the Working Group to take a number of steps in developing presentations and evaluating the utility of these indices (SC-CAMLR-XIX, Annex 4, paragraphs 3.51 and 3.52). In addition, the Scientific Committee noted that it would be useful for the Working Group to consider what might be considered to be the norm in such ordination plots and, as such, what might be a significant departure from the norm. To that end, it might be premature for the Secretariat to routinely present the information in this way until the properties of this, the CSI, and other methods might be better understood, particularly as the Working Group works towards developing a management procedure. Members are encouraged to continue work on developing methods to utilise CEMP data in making decisions on the status of the krill-centric ecosystem.

3.23 The Working Group noted that analyses of several acoustic surveys and commercial catches indicated that krill biomass densities may range from less than 1 to several hundred g m^{-2} , but that viable fishing concentrations require a threshold of 100 g m^{-2} corresponding to catch rates of 3 to 3.5 tonnes hr^{-1} . The Working Group encouraged further analyses to compare the distribution of fishing effort with that predicted from the results of krill surveys and with the distribution of predator demand, and that such investigations be undertaken by Members with relevant data in all regions of Area 48 (Annex 4, paragraphs 4.19 to 4.28).

3.24 The Working Group noted that it was particularly important to develop hypotheses on the origin and transport of krill and to analyse datasets describing krill demography and distribution in the context of these hypotheses. An understanding of the relative contribution of flux and local retention of krill within different regions may be important to allocating precautionary catch limits to SSMUs and may have implications for the use of the GYM, which currently assumes a single krill population (Annex 4, paragraphs 4.20 to 4.36).

3.25 Prof. Beddington endorsed this general approach to achieve the goal of an improved understanding of krill demography and distribution. Dr Naganobu noted that the South Shetland Islands area was quite complex in terms of hydrography which would present difficulties. Dr Hewitt noted that there were many datasets on krill demography and distribution in the Scotia Sea that should be collectively analysed and that structuring the work in terms of hypotheses would be the best way to proceed to achieve an understanding of the distribution and structure of krill populations.

3.26 The Scientific Committee noted that the Working Group reviewed a number of papers describing foraging tactics and reproductive success of penguins and fur seals in relation to prey availability and other environmental factors. In particular, the 2002/03 season was characterised as one of poor reproductive performance for fur seals breeding at Cape Shirreff (South Shetland Islands), with longer foraging trips, lower frequency of krill in the diet, above-average pup mortality and decreased female survival and natality. The Working Group further noted that this study provided new information on possible CEMP indices for monitoring fur seal performance (Annex 4, paragraphs 4.37 to 4.51).

3.27 Several recent studies describing changes in the physical environment of the Southern Ocean during the latter part of the 20th century and biological responses to these changes were reviewed. The Working Group noted two important issues for CCAMLR: (i) responses to climate change are likely to be regional, and possibly site specific; and (ii) interactions with fisheries may confound responses ascribed to environmental change. Given the number of indications of environmental change in the Convention Area, the Working Group considered that it may be appropriate to produce a coherent overview of environmentally induced variability in the Southern Ocean and to consider potential scenarios that might influence ecological relationships with implications for fisheries management (Annex 4, paragraphs 4.54 to 4.59).

3.28 Dr Hewitt noted that the Working Group reviewed a series of papers on the utility of indices derived from mackerel icefish that may be useful in describing changes in the krill-centric ecosystem and encouraged similar analyses of these indices as applied to the CEMP indices in preparation for the CEMP Review Workshop. These studies should include comparisons with other CEMP and non-CEMP indices from similar locations and reflect krill

availability over similar temporal and spatial scales (Annex 4, paragraphs 4.77 to 4.85 and Appendix D, paragraphs 98 to 100).

3.29 The Working Group noted that mackerel icefish was a harvested species, was dependent on krill over some portions of its range and was also preyed on by some of the CEMP indicator species. The Working Group recognised that assessment of ecological relationships and trophic interactions involving exploited fish stocks would require closer collaboration between WG-EMM and WG-FSA, and further requested advice from the Scientific Committee as to how this may be incorporated into the work of these groups (Annex 4, paragraphs 4.88 to 4.92).

3.30 Dr Everson referred to the indices listed in Annex 4, paragraph 4.82, and referred the Scientific Committee to the report of WG-FSA. He noted that the precise mechanism of how the standing stock was derived has changed and that this index would require consistent methods and areas to be of utility. He further noted the data on condition and diet were most likely to be found in national databases.

3.31 The Scientific Committee endorsed the recommended changes to the *CEMP Standard Methods*, Part IV, Section 5, for the collection of tissue sample to be used to detect chemical indicators of metabolic stress and pollutants (Annex 4, paragraph 4.100 and Appendix E) and to Standard Method C2 (fur seal pup growth rate) as outlined in Annex 4, paragraph 4.104.

Allocation of Krill Catch Limit among SSMUs

3.32 In 2000 the Commission adopted a precautionary catch limit for Antarctic krill of 4 million tonnes in Area 48 and further subdivided the catch limit among Subareas 48.1, 48.2, 48.3 and 48.4 (CCAMLR-XIX, paragraphs 4.16 and 4.17). Concern remained, however, that localised depletion of krill populations could still occur if a large portion of the catch was concentrated in a small part of a subarea. Accordingly, the Commission requested advice from the Scientific Committee as to how the catch limit may be further subdivided so as to reduce potential adverse impacts on land-breeding predators (CCAMLR-XIX, paragraphs 9.16, 9.17 and 10.9 to 10.12).

3.33 In 2002 the Commission established 15 SSMUs in Subareas 48.1, 48.2 and 48.3 and directed the Scientific Committee to consider how the krill catch limit could be allocated among the SSMUs (CCAMLR-XXI, paragraphs 4.5 to 4.8). At its 2003 meeting, the Working Group considered four options that defined the catch limit for an SSMU as:

- (i) proportional to the combined estimated predator demand for krill in that SSMU. This option is predicated on the assumption that a high predator demand implies a high standing stock of krill and/or a high turnover rate;
- (ii) proportional to the estimated standing stock of krill in the SSMU. This is based on the assumption that in all areas where krill occur, emigration balances immigration and high krill biomass densities imply high availability;
- (iii) proportional to the estimated standing stock of krill in the SSMU, less the estimated annual predator demand. This is based on the premise that the amount of krill allocated to the fishery should be determined only after accounting for

predator needs. Should the estimated standing stock of krill for an SSMU be less than the predator demand, the catch limit for that SSMU should be zero;

- (iv) an annually adjustable proportion of the catch limit specified by one of the static options (i) to (iii), where the proportion would depend on the value of an ecosystem monitoring index or a combination of indices. This option may be particularly pertinent for SSMUs where there is a wide range of predator reproductive success associated with large changes in krill availability.

3.34 The Scientific Committee noted that comparing allocations among SSMUs using available data results in the following qualitative conclusions:

- (i) Approximately 65% of total demand for krill by land-based predators in the Scotia Sea is in the vicinity of South Georgia. Under option (i), a correspondingly high proportion of the catch would also be concentrated in this area.
- (ii) Option (ii) leads to a more conservative allocation of catch limits among SSMUs with respect to land-based predators, with approximately 75% of the catch limit being allocated to the pelagic SSMUs.
- (iii) Under option (iii), the proportion of catches allocated to the pelagic SSMUs would increase to approximately 83% and no catch would be allowed in the South Georgia West SSMU.
- (iv) Despite the increased allocation to pelagic SSMUs in options (ii) and (iii), annual variations in krill availability may still result in sufficient competition between land-based predators and the krill fishery for predator demand to exceed the krill standing stock in some SSMUs in some years. Option (iv) was designed to take account of this, however for its implementation, improved indices for krill availability and/or transport into an SSMU may need to be developed.

3.35 At WG-EMM, several members noted that a key implication of subdivision options (ii) and (iii) was a very substantial redirection of krill fishing effort to the pelagic SSMUs, and that this contrasts strongly with the present situation. If indeed the krill catch does increase substantially from its present level, in their view it would not be possible to continue to take the catch from a small number of SSMUs adjacent to predator colonies, either in terms of meeting the needs of the predators or of maintaining an economically viable fishery. In their view, some redistribution of krill fishing effort, particularly towards SSMUs not immediately adjacent to land-based predator colonies, was a desirable and necessary response to substantially increasing krill catches. It was noted, however, that a corollary of a shift to pelagic SSMUs may be that fishing would be taking place in areas in which the fleet had not operated regularly in the past, and for which levels of monitoring were low.

3.36 Other Members argued that competition between fishing vessels and krill predators needed to be proved before appropriate management action can proceed. They also noted recent increases in some predator populations (e.g. fur seals in Subarea 48.3) and that their effects on ecosystem balance and the conservation principles defined in paragraph 3 of Article II of the Convention remains unknown. It was further argued that biological reference points with respect to predator population sizes needed to be established before it was

possible to allocate the krill catch limit among SSMUs based on predator demand for food. In addition, these Members noted that fishable concentrations of krill were rare and transient in pelagic SSMUs.

3.37 In respect of the suggestions put forward in paragraph 3.36, Prof. Croxall observed that the burden of proof for competition between fishing vessels and krill predators should reflect an appropriate balance between protecting predators at critical periods in their annual and life cycles and avoiding unnecessary dislocation of krill fishing activities. Furthermore, he did not accept that defining biological reference points is a prerequisite for allocation of krill catch limits amongst SSMUs. He recommended that consideration of biological reference points should not proceed until specific proposals, containing appropriate models and indications of the type of management by which target reference points should be achieved, had been received and evaluated by the Working Group.

3.38 Dr Constable noted that the interpretation of Article II with respect to ‘dependent and related species’ also needed to include ‘recovery of depleted populations’ and that these issues had been addressed in part by the Commission in the late 1980s. In that respect, proposals for changing the approach towards dependent and related species and recovering species, such as proposals for reference points, would need to be developed and submitted for review before they could be incorporated as part of an approach to managing the krill fishery.

3.39 Discussion of the general principles of balancing predator demand and a krill fishery in or near predator foraging grounds raised issues relating to the interpretation of Article II of the Convention which were outside the remit of WG-EMM. These were referred to the Scientific Committee for further consideration.

3.40 The Scientific Committee agreed that an additional option that considers both survey data and historical krill fishing information should be developed, and in order to do so it is essential that all information on historical, current and future krill fishing activities be made available on a fine spatial and temporal scale. The Scientific Committee noted that intersessional work on this topic is required in order that further progress on the subdivision of the precautionary catch limit among SSMUs can be made at the next meeting of WG-EMM.

3.41 It was noted that for the krill catch to exceed 620 000 tonnes, agreement would have to have been reached for the allocation scheme of the precautionary catch limit amongst SSMUs.

3.42 It was noted that the Commission requested recommendations for a subdivision of the precautionary catch limit in Area 48 this year and that further discussion of this topic would take place next year after the WG-EMM modelling workshop.

3.43 The Scientific Committee noted that these options will be considered in discussions that will take place over the next year. The Scientific Committee would welcome any additional options that would allow progress to be made on this issue.

Future Work of WG-EMM

3.44 Following further discussion by the correspondence group on land-based predator surveys, the Scientific Committee endorsed the Working Group plan to initially focus on

colonial-breeding penguins, which as a group is both the most tractable of the land-based predators for broad-scale survey and major consumer of krill. Rather than attempting surveys at circumpolar scale, a more prudent approach would be to select a few regions for pilot studies to evaluate methodologies, followed by broader-scale application of evaluated methods depending on the results of such pilot studies. Further, pilot studies would best focus on regions in East Antarctica and the lower latitudes of West Antarctica, which provide contrasting complexities for surveys and therefore likely differing feasibilities (Annex 4, paragraphs 6.1 to 6.12).

3.45 The Working Group noted that, in accordance with its long-term work plan, it would hold a workshop during its 2004 meeting to develop plausible operating models of the Antarctic marine ecosystem. These models can then be used to test and evaluate candidate management procedures during a workshop scheduled to be held during the 2005 meeting of WG-EMM. The conceptual framework of this two-step process is described in Figure 1, where an operating model describes how the natural world works and how a fishery interacts with it (the left side of the figure). A management procedure includes the operational objectives derived from Article II, the collection and analysis of observational data, and the application of decision rules (the right side of the figure). The Working Group agreed that evaluation of a management procedure would be undertaken by simulating its performance under various operating models. The robustness of a management procedure in meeting the objectives of the Convention, despite the uncertainties of the operating model and parameter estimates, could thus be evaluated (Annex 4, paragraphs 6.13 and 6.14; Figure 1).

3.46 The Scientific Committee endorsed the Working Group's plan that the 2004 workshop would be titled 'Workshop on Plausible Ecosystem Models for Testing Approaches to Krill Management' and endorsed the terms of reference for the workshop developed by the steering committee convened by Dr Constable (Annex 4, paragraph 6.17). Additionally, the Scientific Committee endorsed the intersessional work plan developed by the steering committee and welcomed any interim progress reports that may be developed prior to the 2004 meeting of WG-EMM. The Working Group also requested the approval of the Scientific Committee to invite modelling experts and noted that this may have budgetary implications (Annex 4, paragraphs 6.20 to 6.22).

3.47 Dr Constable reported that an ad hoc group of available members of the steering committee met during the Scientific Committee meeting to consider how to proceed and prepare for the workshop. They reiterated the importance of asking Members to involve national experts in the preparations for the workshop and also in the workshop itself. Additionally, it was highly desirable to similarly involve two invited experts in the entire process.

3.48 Preparations include a review of the relevant literature on ecosystem models and software, consideration of requirements for datasets and parameters of interest, and development of an outline of the aims and specifications for ecosystem modelling as it relates to the development of management procedures for krill. Modelling components will include, as appropriate, a food-web model, the environment, the fishery, life history and physiological models and spatial aspects of the ecosystem.

3.49 Members noted the synergy between the work of both WG-EMM and WG-FSA and that the outcome of the workshop would provide a good opportunity to determine the most appropriate mechanism by which to optimise the work of the two working groups.

3.50 The Scientific Committee endorsed the Working Group nomination of Drs Reid and Watters to co-convene the workshop on management procedures to be held during the 2005 meeting of WG-EMM (Annex 4, paragraph 6.25).

3.51 On behalf of the Working Group, Dr Hewitt presented a long-range work plan to the Scientific Committee (Table 1), which outlined the major issues and a timetable for addressing them. The work plan was organised around five broad issues:

- (i) Subdivision of the precautionary catch limit for krill in Area 48 –
The Working Group welcomed initial proposals at its 2003 meeting, encouraged submission of additional proposals in 2004, and noted that it had indicated that it would forward a recommendation to the Scientific Committee at its 2004 meeting. Most participants agreed that this was possible, although some felt that additional time may be required in order to achieve a consensus recommendation.
- (ii) Revised krill management procedure –
Following successful workshops on defining SSMUs in Area 48 and the CEMP review, the Working Group noted that work is progressing according to plan with preparations under way for a workshop on operating models to be held in 2004. With regard to the workshop on management procedures to be held in 2005, the Working Group renewed its request for operational definitions of Article II. The Working Group also noted that reporting requirements from the fishery and monitoring requirements from CEMP will need to be revised.
- (iii) Assessment of predator demand –
The Working Group noted that assessment of predator demand will progress from the present discussion phase to consideration of pilot studies in 2004 and 2005.
- (iv) Subdivision of large FAO statistical areas –
The Working Group noted that the ad hoc Subgroup on Harvesting Units expects to forward recommendations for subdividing Subareas 48.6, 88.1, 88.2 and 88.3 and Divisions 58.4.1 and 58.4.2 to the 2004 meeting of WG-EMM.
- (v) Strategic planning –
The Working Group recalled the Workshop on the Future Agenda of WG-EMM held in 2001, and considered that a similar workshop to consider planning beyond 2005 may be necessary. A planning session for such a possible workshop is scheduled in the revised long-term plan for 2005. One topic could be consideration of whether the Working Group should expand the scope of its work from its current krill-centric focus to include other species and systems (Table 1; Annex 4, paragraphs 6.29 to 6.42).

3.52 The Scientific Committee noted that these plans involved a tremendous amount of work which would require intersessional activities and that work should be well advanced on the development of a management procedure for krill before other substantial work programs are initiated. It also noted that work on specifying the future CEMP should begin in 2005 with discussions on management procedures when monitoring will be an important consideration, rather than in 2004. Nevertheless, the Scientific Committee encouraged the

continuation of work on existing CEMP parameters discussed by WG-EMM in time for consideration next year.

3.53 In relation to paragraph 3.51(v), Prof. Croxall, while noting the value of examining the population trends in various ecosystem components, recommended a continued focus on the krill-centric ecosystem. This would not preclude Members from addressing other species.

3.54 Prof. C. Moreno (Chile) noted that the current system is influenced by human perturbations of the past and commented on the value of historical data in modelling efforts. Dr Constable agreed that historical papers could provide data useful to help model future ecosystem trends.

Non-krill Centred Ecosystem

3.55 In addition to consideration of the krill-centric system, considered at WG-EMM, WG-FSA had considered ecosystem pathways that were centred on fish.

3.56 In this context, WG-FSA had encouraged future work to develop methods to incorporate data on interactions between mackerel icefish and upper-trophic level predators into assessment procedures and into ecosystem models involving mackerel icefish as outlined in Annex 5, paragraphs 8.2 to 8.5.

3.57 The Scientific Committee noted that WG-FSA had reviewed a proposed method for using the diet of Antarctic shags (*Phalacrocorax bransfieldensis*) to monitor the abundance of young life history stages of coastal fish species, including those subject to CCAMLR conservation measures. The Scientific Committee considered that the method had been thoroughly evaluated and that future studies of the composition of the fish diet of Antarctic shags should follow this method. The Scientific Committee agreed that the index had the potential to provide information on ecological relationships and changes in populations of certain fish species.

3.58 The Scientific Committee noted that time-series of data of fish composition in the diet of Antarctic shags have the potential to provide useful information to the work of WG-FSA, and Members were encouraged to liaise with the Secretariat on the submission of such time series of data that had been collected following the methods developed for this study (Annex 5, paragraphs 8.6 and 8.7).

3.59 Dr E. Barrera-Oro (Argentina) noted that the monitoring method that uses the diet of Antarctic shags was also applicable to adult stages of many demersal fish species. He pointed out that the aims of this methodology include the monitoring of changes in the abundance of juvenile stages of some fish species that have been the subject of commercial exploitation in the past.

3.60 The Scientific Committee acknowledged the efforts of Argentina and encouraged them to continue their work with Antarctic shags.

3.61 The Scientific Committee recognised the value of using other components of the ecosystem to assist in monitoring trends in fish species that have in the past been affected by human exploitation.

Advisory Subgroup on Protected Areas

3.62 Dr Hewitt summarised the work of the Advisory Subgroup on Protected Areas. Tasks included a review of the status of CEMP site maps and the guidelines for producing maps, a review of the terms of reference of the subgroup, and a review of the membership of the group (Annex 4, paragraphs 5.1 to 5.9).

3.63 Prof. D. Torres (Chile) called attention to SC-CAMLR-XXII/BG/14 'Management Plan for ASPA No. 145 (SSSI No. 27)'. After discussion as to the appropriate pathway and timing for review by CCAMLR, the Scientific Committee recommended that the plan be referred to the Advisory Subgroup on Protected Areas for review during the 2004 meeting of WG-EMM. It was noted that the intent of the Scientific Committee was to follow adopted procedures, while at the same time not delaying the review process unnecessarily.

3.64 Dr K. Sullivan (New Zealand) informed Members of New Zealand's plans to submit a Protected Area Management Plan for the Balleny Islands to WG-EMM in 2004.

3.65 Prof. Croxall called attention to the terms of reference related to marine protected areas, i.e. to provide advice on the implementation of marine protected areas that may be proposed in accordance with the provisions of Article IX.2(g) of the Convention, including 'the designation of the opening and closing of areas, regions or subregions for purposes of scientific study or conservation, including special areas for protection and scientific study' (Annex 4, paragraph 5.9(v)). He noted that there were a number of recent worldwide efforts, including studies, conferences and scientific research, which focused on marine protected areas, both along coasts and especially on the high seas. He suggested that it would be timely to bring a summary of this activity to the attention of WG-EMM and the Scientific Committee.

3.66 Prof. Croxall recommended that the Advisory Subgroup on Protected Areas review such recent work related to marine protected areas during the intersessional period and to provide background information to the 2004 meeting of WG-EMM.

3.67 Dr Penhale, chair of the Advisory Subgroup on Protected Areas, indicated that this task would be agreeable to the subgroup and that the revised membership of the subgroup should ensure the inclusion of members with expertise in this area.

3.68 The Scientific Committee concurred with these recommendations.

3.69 The Scientific Committee recommended that the Commission endorse the following terms of reference for the Advisory Subgroup on Protected Areas:

- (i) to review the details of proposals relating to designation and protection of CEMP monitoring sites and review of CEMP management plans as required in accordance with Conservation Measure 91-01;
- (ii) to revise and keep under review, as appropriate, guidelines for the production of maps of protected areas relevant to CCAMLR;
- (iii) to develop and keep under review, as appropriate, a methodology for assessment of proposals for marine protected areas forwarded in accordance with

Article 6(2) of Annex V of the Protocol on Environmental Protection to the Antarctic Treaty;

- (iv) to provide advice on marine protected areas that seek designation as an ASPA or an ASMA under the Antarctic Treaty;
- (v) to provide advice on the implementation of marine protected areas that may be proposed in accordance with the provisions of Article IX.2(g) of the Convention, including 'the designation of the opening and closing of areas, regions or subregions for purposes of scientific study or conservation, including special areas for protection and scientific study'.

Advice to the Commission

3.70 Following the CEMP Review Workshop, the Scientific Committee recommended a third objective be added to CEMP – 'to develop management advice from CEMP and related data' (paragraph 3.14(i)).

3.71 Given the current design of CEMP, the Scientific Committee noted that it may never be possible to unambiguously attribute causes of ecosystem change to either the actions of the krill fishery or to environmental change, and requested advice from the Commission regarding policy of how management should proceed when a significant change was detected but no single causal factor could be attributed (paragraph 3.12(iii)).

3.72 In response to a request from the Commission, the Scientific Committee noted that four options for subdividing the precautionary catch limit for krill in Area 48 among SSMUs were discussed, and called for additional proposals to be developed during the intersessional period with the expectation of forwarding a recommendation to CCAMLR-XXIII (paragraphs 3.32 to 3.43).

3.73 The Scientific Committee requested that the Commission endorse the long-range work plan of WG-EMM, which addressed four main issues: (i) subdivision of the precautionary yield of krill in Area 48; (ii) development of a revised krill management procedure; (iii) assessment of krill predator demand; and (iv) subdivision of large FAO statistical areas into harvesting units (paragraphs 3.51 and 3.52 and Table 1).

3.74 The Scientific Committee recommended that the Commission endorse the terms of reference for the Advisory Subgroup on Protected Areas as laid out in paragraph 3.69.

3.75 The Scientific Committee recommended that the Management Plan for ASPA No. 145 (SC-CAMLR-XXII/BG/14) be referred to the Subgroup on Protected Areas for review at its meeting during WG-EMM in 2004 (paragraph 3.63).